Technical Notes ON BRICK & TILE CONSTRUCTION

VOL. 5 NO. 8 AUGUST 1954

STRUCTURAL CLAY PRODUCTS INSTITUTE

REINFORCED BRICK MASONRY INSPECTORS' GUIDE — II

INTRODUCTION

Part II of Reinforced Brick Masonry Inspectors' Guide, covering mortar, grouting and workmanship, is reproduced from "Reinforced Grouted Brick Masonry Field Inspectors' Handbook," published by the Clay Brick and Tile Association of San Francisco. For acknowledgments, see Part I, Technical Notes, Vol. 5 No. 7, July 1954.

MORTAR AND JOINTS

It goes without say that cement and lime used in mortar should pass ASTM specifications. The sand is just as important also, and should be graded with sufficient fines to make a plastic and cohesive mortar. This is described by the bricklayer as a "good fat mortar". The ASTM designation C144-, "Aggregate for Masonry Mortar," specifies that 2 to 15 per cent of the sand shall pass through the No. 100 sieve. The typical coloring admixtures for mortar act as an increase in fines (increasing workability), and probably a sand with less than 4 per cent passing the No. 100 sieve will be satisfactory when coloring admixtures are used. Sand grading is more important today than in years past, due to the fact that very high cement mortars are commonly specified, such as 1C:1/4L:3S.

Importance of Lime. It is recognized that the inspector cannot change the specified mortar mix, but can only check on the ingredients and mixing on the job; for instance, no more lime and no less lime than specifications allow. However, the inspector can consult with the architect or engineer, when there is a mortar difficulty on the job, and explain how a change in mortar specifications will improve bed joint bond, mortar workability or whatever the trouble is. The absence of lime in the amount of 25 per cent (or more) of the cement causes the mortar to be harsh. Mortars of this type test high in compression, but may have lower bond strengths with brick than mortars of higher lime content. Test results show that under most circumstances the best bond values of brick to mortar in the field (important in earthquake zones for shear strength of the wall) are obtained with a moderate 1C:1/2L:4 1/2S mix, which is adequate in compression. Therefore, lime is just as important to a mortar mix as are cement and well graded sand.

An important value of lime in a mortar mix, besides making the mix "fat" and workable, is to increase the water retentivity of the mortar. This is especially important during hot weather when dry brick might suck the mortar dry. Therefore, any concrete admixtures to increase workability should not be used unless tests indicate that such admixtures do not decrease bond between mortar and brick or between grout and reinforcement.

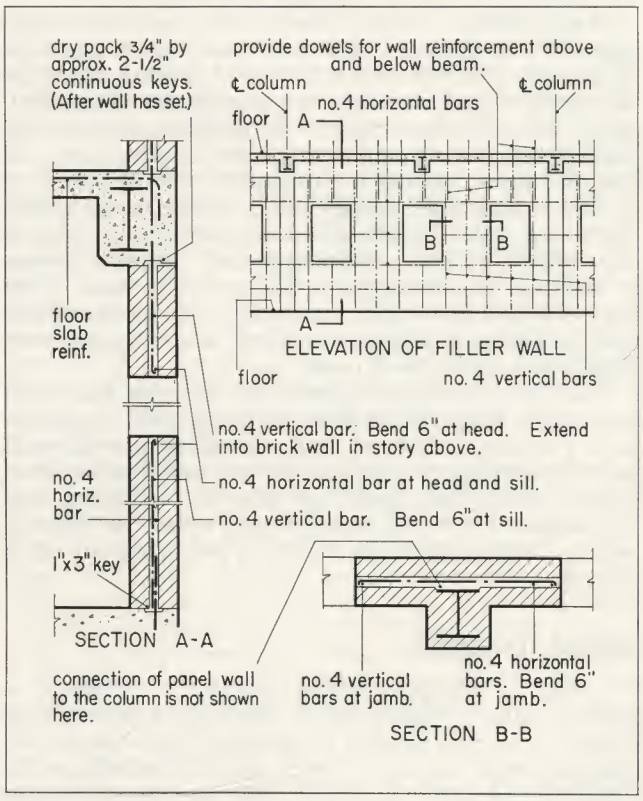

Fig. 1

Vertical wall reinforcement.

Mortar bond to brick is just as important in RBM as it is in plain masonry. Therefore, the inspector should check the bond of the mortar to the brick at the beginning of masonry work by lifting a brick several minutes after it has been laid. If the mortar does not adhere to the lifted brick, but instead breaks away leaving a clean brick, the inspector should immediately notify the architect or structural engineer and request corrective measures.

Bed Joints. The preparation of the mortar bed joint is important and should be made in such a

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manner that mortar droppings will not accumulate in the grout space. This is because dry mortar cannot develop bond, and therefore is detrimental to good work. A good technique is for the bricklayer to lay the bed joint so that the inside edge is slightly thinner than the outside edge. This bevel, slanting along the inside grout core, leaves no excess mortar protruding beyond the brick. If there is an excess of mortar when the brick is shoved down in place, a mortar fin sticks out from the bed joint. First of all, this should not happen; but, if it does, the bed joint fin should be left there and not cut down with a trowel to fall into the grout space below. See Fig. 2 for examples of good and bad bed joints.

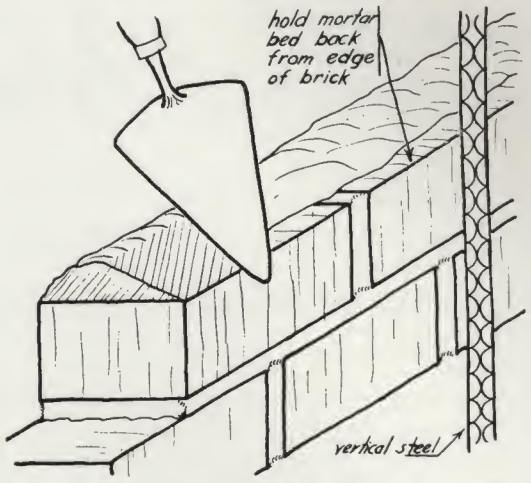
Head Joints. Head joints shall be full. Years ago, it was believed that the head joint could be made only half full with trowel and mortar, and that the grout would flow into the remainder of the head joint and fill the voids. Experience shows that sometimes it does and sometimes it does not. It has also been claimed in the past that the grout, as it fills a half-filled head joint, provides an additional key and makes the wall stronger. This is not proved by test experience, and there is reason to believe that incomplete filling of the head joint may weaken the wall. Virtually all specifications require the head joints to be filled, and the inspector should see that this is done.

The best joints are formed by shoving the brick into place, and this is now standard good construction practice. Shoved joints produce a solid wall section, leaving no cavity in which water can collect during prolonged rainy periods to be drawn out ultimately by warm weather and result in efflorescence. Methods of forming head joints are shown in Fig. 3.

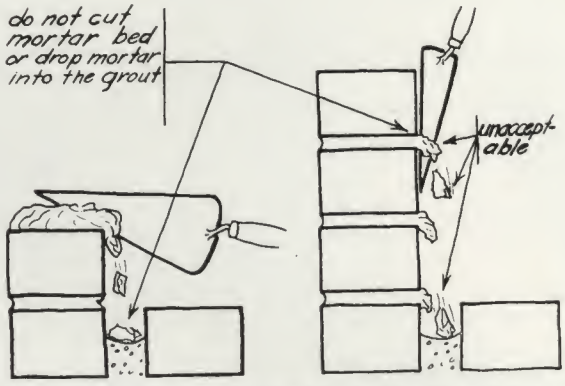
GROUT HANDLING

Grout is different from concrete. Concrete is poured with a minimum of water into non-porous forms. Grout is poured with much more water into porous forms (brick). Grout should be sufficiently fluid to flow into the collar joint and surround the steel, leaving no voids. It should be wet enough to prevent rapid stiffening. Whereas good mortar should stick to the bottom side of a trowel, it should be impossible for grout to do so. The water/cement ratio as mixed, highly important in concrete work, is of lesser importance in grout for brick masonry. When introduced into the wall, the water/cement ratio of grout is rapidly and automatically changed from a high to a low water/cement ratio. Although excessive water is detrimental, usually the case is that the grout is too dry and, therefore, too stiff. Claims have been made in the past that, because grout shrinks inside the wall, mortar should be used in its stead to surround the steel and bond the wall together (this is called "slushed" masonry), because it would be stronger. Tests show that this is not true, since, if the brick are properly wet, grout shrinkage is very minor. Only by grouting can all the voids in the wall be filled.

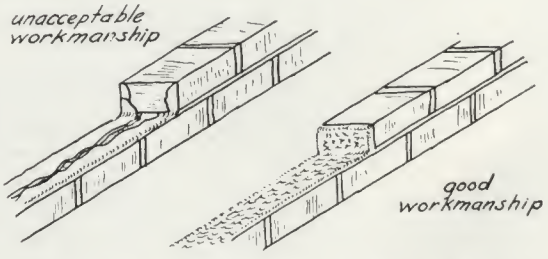
Accepted good practice is to lay the outer tier of brick 3 or 4 courses high, then to lay the inner tier and follow by grouting, course by course. When



The beveled bed joint can best be made as seen here. It is very important for the bricklayer not to spread so much mortar on the joint that, when the brick are shoved in place, a "fin" protrudes from the brick into the grout space. Furrowed joints, made by plowing the center of the bed joint with the tip of the trowel, are not acceptable.

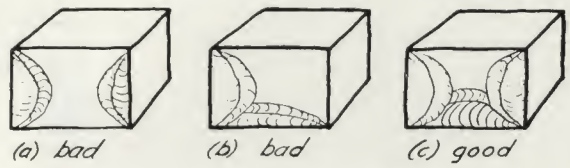


An excess of mortar on the bed joint will result in fins which extend into the grout space. These fins interfere with proper grout flow. However, if they occur, they should not be cut off, since all too often they fall into the grout space below. For these reasons, the bed joint should be beveled.



If a stretcher brick is lifted from the wall several minutes after it has been laid, the mortar should appear as seen in the sketch at right (rough and uneven), rather than as shown in the sketch at the left where a clean break between mortar and brick and a deeply furrowed bed joint can be seen.

Fig. 2
Bed joints.



Head joints must be full either with grout or mortar. It is generally believed that grout will not flow into a half filled head joint to fill the void. However, if the head joint is larger than ½ in. in thickness, the grout, if puddled properly, will fill the void. Practical experience has shown that a head joint, buttered as in sketch (a), will not be filled when shoved, and will not later fill with grout. Head joints buttered as in sketch (b) will not be filled when shoved, and will not fill with grout unless they are larger than the ½-in. thickness which is generally used. Head joints buttered completely or ¾ full, as seen in sketch (c), are good under almost any conditions.

Fig. 3
Head joints.

roman or other brick 1½ in. in height are used, the outer tier should be carried up 6 or 8 courses high, or twice as many courses as for a 2½- to 3½-in. brick. This way one wall is always 8 to 12 in. ahead of the other during laying. About 15 min. should pass between successive grout pourings at any point in the wall. This is so that the grout will have a chance to stiffen. If grouting is carried on too rapidly, for example within 3 min. at any point in the wall, there is a chance that the hydrostatic pressure of the grout will cause a "blowout" of the top courses of brick. This is true especially if both grout and the brick are too wet, and the grout core is wide, i.e., 2½ to 4 in.

Blowouts on Wall. To avoid blowing out the wall, the work must be spread out along the wall, with bricklayers not closer than 10 to 15 ft. When bricklayers get bunched up working too close together and the grout is carried up too rapidly, there is a chance that the wall will blow out. Experienced crews rarely do this, but inexperienced contractors might do this on their first grouted brick job. If the wall does blow out, even as little as ⅛ in. out of plumb, the work must be torn down and done over. This is because the bed joint bond has been destroyed, and the bed joint cannot be repaired merely by shoving the wall back in plumb.

Grout must be well stirred before using to avoid segregation of the aggregate. It should be carefully poured, preferably with buckets equipped with spouts such as coal scuttles which are ideal. This is to confine the grout to the grout space and not splash or slobber it onto the faces or top surfaces of the tiers of brick. Dried grout on top of a brick is detrimental to the bed joint bond. The grouting operation may be done in two or more passes and the total height should be from the center of one course to the center of the course above. It is advisable to do this (keep grout pour at or below the center of the top course of brick) to prevent rotation of the brick due to suction of the grout on the brick. If the brick rotate, it has a bad effect on the mortar joint bond.

On any walls larger than two tiers of brick in thickness, there is a generally accepted technique for placing the inside tier of brick in the grout. First, the bricklayer lays up the two outside tiers of brick and pours grout in the grout space in the customary manner. Immediately after this, he takes a brick and floats it in the inside tier. By "floating" is meant the brick is pushed 1 in. to 1½ in. down into the grout.

Grout in contact with brick solidifies more rapidly than that in the center of the grout space. It is, therefore, important to puddle or agitate the grout *immediately* after pouring to prevent disturbing the solidified portion next to the brick. The best procedure is to have two masons perform this operation jointly; one to pour the grout and the other to puddle. Puddle sticks cut from ¾-in. by 1-in. wood are the most practical size. Puddle sticks too big or puddling too late or too deeply will cause the wall to blow out. A good procedure is to whittle one end of the stick into a handle. This has two advantages: first, it is easier to use; and second, it emphasizes the fact that the sticks have a purpose and should not be swept up at the end of the shift with other debris. When reinforced grouted brick masonry was first coming into widespread use some years ago, it was recommended that a trowel be used for puddling the grout core. Since then, it has been the experience of many inspectors that a grout stick will do a better job, particularly with grouts of average consistency.

It is best to bring all tiers to the same level and the grout to within ¾ in. of the top if operations on the wall are suspended for a period of more than 1 hr. This increases the bond of the next pour of grout. The final pour of grout for the day should be between two tiers of brick (for 8-in. walls) of equal height and poured to within ¾ in. from the top to help cleaning operations when the work is resumed.

If indicated on the plans (as it usually is), the reinforcing steel must be kept centered in the grout space to provide adequate embedment of the steel and "balance" the wall strength. Vertical reinforcing steel shall be held firmly in place by means of 2-in. by 4-in. frames, odd lengths of reinforcing steel, or anything else that will do the job. Horizontal steel should be placed by the bricklayer as the work progresses. Care shall be taken to prevent movement or jarring of vertical reinforcing while masonry is being placed.

GROUT INGREDIENTS

The two kinds of grout normally used are sand grout (consisting usually of the mortar mix to which water has been added to make it flow) and pea gravel grout which is sand grout to which pea gravel is added equal to twice the volume of the cement. For pea gravel grout, the pea gravel should be well graded ⅜-in. maximum size.

Sand grout under certain conditions is a satisfactory medium, but is susceptible to excessive shrinkage cracks, probably due to the additional water that must be added to make it easily pourable. Some of these cracks are small and of little consequence, and

some are large enough to produce cleavage lines in the center and at the edges of the grout space, resulting in a wall section which is not monolithic. To avoid these cracks, it is recommended that (1) wetter brick and (2) grout with slightly less water content be used together with moderate puddling.

Pea gravel grout contains a smaller amount of water and less cement than sand grout and results in less shrinkage due to the greater mass of the individual aggregate. Cut cross-section specimens show, contrary to some opinions, that there is no segregation of aggregates in a vertical direction, probably due to the small height of the pour and rapid dehydration of the grout. Many cross-section cuts through walls indicate this. In reality, the aggregate appears on the surface of the grout, thereby producing an effective bond surface. If the inspector observes shrinkage cracks, or any shrinkage cracking in the head joints, he should direct this to the attention of the architect or structural engineer. For practical purposes, an excessive shrinkage crack in the grout is anything longer than 2 in. and having a depth of over ¼ in.

TEST SPECIMENS

When required to be taken by the building code or the specifications, test specimens for mortar must be made in waxed paper containers (or equal, such as ice cream cartons) having a length-to-diameter ratio of 2 to 1. If in doubt as to the procedure in the preparation of the specimens, consult your laboratory.

CONCLUSION

These recommendations are intended to outline to the inspector the procedures which have been found by experience to be satisfactory ones for obtaining good workmanship in Reinforced Brick Masonry. Differences between these recommendations and the requirements of the specifications must be adjusted before proceeding with the work. The best work is obtained when contractor and bricklayer understand the reasons for these requirements, and often the inspector is the only one available to enlighten the field crew. The inspector should also be able to advise the architect and structural engineer of actual job conditions, and explain any important conditions in the masonry that require change.